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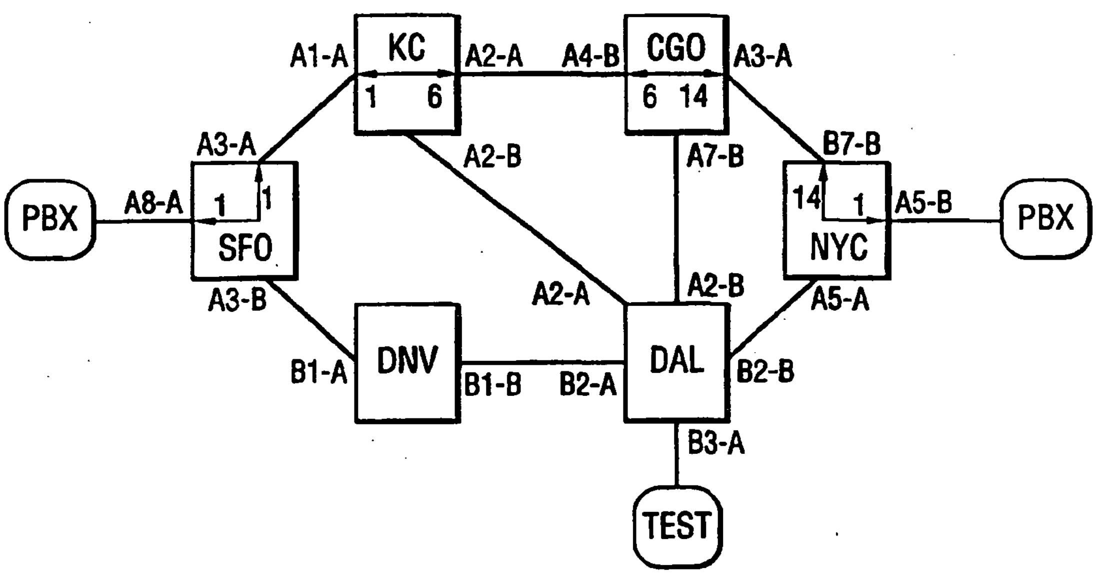

(57) Abstract

A method is described for monitoring a network having a plurality of nodes, wherein a path is set up to carry traffic between two points on said network. A test device is set up at a test site, cross connections are set up between the test site and the nodes on the path, and the path is monitored through the cross connections.

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SPLIT AND MONITOR MAINTENANCE CONNECTIONS

This invention relates to a method and arrangement for monitoring the status of a network, and more particularly to a split and monitor maintenance connection.

The point-and-click paradigm used in the applicant's 4602® Network Management System for the set-up of connections (called paths) in a network is unique. The path set-up feature is based on the end-user selecting the two endpoints and using a "connect" request. The connect request causes the 4602 to optimally route the path through the network.

Since paths form a critical component of any customer's network, it is important that the customer be provided with a means of diagnosing problems efficiently and cost effectively.

One solution is for users to manually set up tests (provided they have access privileges to the equipment). This solution, however, is laborious and costly both in terms of time and money.

An object of the present invention is to alleviate the aforementioned problem.

According to the present invention there is a method of monitoring a network having a plurality of nodes, wherein a path is set up to carry traffic between two points on said network, said method comprising the steps of providing a test device at a common test site for the network; setting up cross-connections with a network manager at a single location between said test device and said nodes on said path; and monitoring said path through said cross-connections with the aid of said test device.

A split maintenance connection splits a connection such that each end of the connection is routed to a test device. A monitor maintenance connection allows listen-only maintenance on a live traffic path.

Monitor connection maintenance allows the maintenance circuits to act as additional destination circuits for the data being carried by the target connection. The data carried between the target circuits is not disrupted in any way.

The split and monitor maintenance connections provided by the invention offer a means of advanced path diagnostics to initiate maintenance on a connected path to test connections and path integrity.

A point-and-click paradigm is preferably employed to perform the above maintenance connections from the single location. The user can select the circuit and the test circuits on which maintenance has to be performed and invoke a split or monitor connection. The concept also provides the ability to "undo" a maintenance connection and restore the circuit under test to the original connected state. The system inherently checks for the access privileges of the operator before proceeding with the maintenance operation request.

This system can save network operators much time and money because the entire network can be monitored from the network manager using common test equipment that can be maintained at one common location.

A maintenance connection allows access to a target connection such it can be tested for integrity. Each maintenance connection requires a target connection and two maintenance circuits.

A monitor maintenance connection is a non-intrusive maintenance action. The target circuits of the monitored connection are each routed to a maintenance circuit where a test can be performed without affecting service.

A split-back maintenance connection is an intrusive maintenance action which splits a target connection such that each end of the connection is routed to its respective maintenance circuit.

A split-through maintenance connection is an intrusive maintenance action which inserts the maintenance circuits in the data and signaling path between the target circuits.

A target circuit is either one of the two circuits involved in a network manager or NMTI connection that is to be maintained. It is located on the path-under-test; it is also referred to as a pathpoint.

A target connection is the connection to the network manager that the user wishes to apply a maintenance connection on. Once the maintenance connection is established the target connection can be tested.

Terminate and leave maintenance provides the ability to apply trunk conditioning at the output of a target circuit without removing the target connection.

Test equipment includes devices such as BERTs (Bit Error Rate Tester) which are used to test maintained connections.

The invention will now be described in more detail, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 shows a typical network with centralized test equipment;

Figure 2 shows a typical network under maintenance;

Figure 3 shows a split-through subrate channel from composite HCM DS0;

Figure 4 shows a split-back subrate channel from DDS DS0A;

Figures 5a to 5c show split-back maintenance on a preferred connection;

Figures 6a and 6b show split-back maintenance on a protection connection;

Figure 7 shows a network path with protection;

Figure 8 shows maintenance on an alternate path while the primary path is active;

Figure 9 shows Maintenance on primary path while alternate path is active;

Figures 10 and 11 are state diagrams giving the transitions for target and maintenance circuit statuses; and

Figure 12 is a state Diagram for Target Connection Status.

An example of the usage of connection maintenance for wil now be described with reference to Figure 1.

Suppose a T1 network is setup as shown in Figure 1. Two PBX's (Private Branch Exchanges) 1, 2 have respective T1 interfaces in San Francisco, attached to link SFO A8-A, and New York, attached to link NYC A5-B. Further, a T1 test set 3 with DS0 test capability is attached to Dallas link B3-A.

A path between the two PBX's is set up, using the following cross-connections under the control of a Newbridge Networks Corporation 4602® network manager:

SFO A8-A-1 to A3-A-1 KC (Kansas City) A1-A-1 to A2-A-6
CGO (Chicago) A4-B-6 to A3-A-14 NYC B7-B-14 to A5-B-1.

This path is shown with a heavy line in Figure 1. When the user of a PBX 1, 2 complains of noise on the path, the craftsperson must find the source of the noise, but is not allowed to remove any of the connections on the path.

The craftsperson first establishes connections between the link to the coommon test set 3 and links to the nodes to be tested. The following cross-connections are established:

DAL B3-A-1 to B2-A-23 DAL B3-A-2 to B2-A-24

DAL B3-A-3 to A2-A-23	DAL B3-A-4 to A2-A-24
DAL B3-A-5 to A2-B-23	DAL B3-A-6 to A2-B-24
DAL B3-A-7 to B2-B-23	DAL B3-A-8 to B2-B-24
DNV (Denver) B1-B-23 to B1-A-23	DNV B1-B-24 to B1-A-24

A customer using centralized test equipment would reserves specific bandwidth to connect that test equipment to the rest of the network.

The maintenance then begins as shown in Figure 2. First, the SFO A8—A-1 to A3-A-1 connection is monitored by A3-B-24 and A3-B-23, to ensure that the connection is not currently carrying an active call. If the connection is currently idle, then T&L maintenance is applied to trunk condition SFO A8-A-1 and NYC A5-B-1; this ensures that the PBX's will not receive the test patterns, and, if "seize" fault signaling has been configured, that the PBX's will not attempt to place calls over those circuits during the test.

Next, the test set 3 is configured to inject a test pattern into circuits 1 and 7. The SFO A8-A-1 to A3-A-1 connection is split-back by A3-B-24 and A3-B-23; this means that the test set's test pattern on circuit 1 is transmitted to SFO A3-A-1, and that the test set receives on circuit 1 whatever SFO A3-A-1 is receiving from the line. Similarly, the NYC B7-B-14 to A5-B-1 connection is split-back by A5-A-23 and A5-A-24; this means that the test set's test pattern on circuit 7 is transmitted to NYC B7-B-14, and that the test set 3 receives on circuit 7 whatever NYC B7-B-14 is receiving from the line. It turns out that the test reports that circuit 1 is receiving error-free data, but that circuit 7 is receiving errored data. Therefore, the path is clean in the NYC to SFO direction, but there are problems in the SFO to NYC direction.

The KC A1-A-1 to A2-A-6 connection is monitored by A2-B-23 and A2-B-24; A2-B-23 is monitoring the SFO to NYC

direction, and the test set's circuit 3 will receive this data. The CGO A4-B-6 to A3-A-14 connection is monitored by A7-B-23 and A7-B-24; A7-B-23 is monitoring the SFO to NYC direction, and the test set's circuit 5 will receive this data. At this point, the network's connections and maintenance are as shown in Figure 2.

The test set reports that circuit 3 is error-free, but that circuit 5 is receiving errors. The problem must be between the KC and CGO connection matrices: either in the line output of KC A2-A-6, the T1 between KC and CGO, or the line input of CGO A4-B-6. The craftsperson applies T&L maintenance to trunk condition CGO A3-A-14; this will prevent the propagation of the noise received at CGO A4-B-6. Finally, all connection maintenance, except for this last T&L, is removed.

Since connection maintenance can only operate on the central switching matrices, this problem cannot be further isolated using only connection maintenance.

No special configuration is necessary to designate a particular circuit as a maintenance circuit. Generally, any primary rate, data or voice circuit in the system can act as a maintenance circuit, as long as that circuit is not involved in a target connection.

However, maintenance circuits may require some configuration to permit them to be used with a particular target connection. Specifically:

- Maintenance circuits must have the same bandwidth requirements as the target connection.

- Maintenance circuits must have a signaling type which allows them to be connected to the target circuits. This can be tricky for voice target connections;

- Maintenance circuits are always bi-directional, even if the target connection is

unidirectional. This is particularly important for maintenance on a unidirectional superrate connection: the maintenance circuit must be configured as a bi-directional superrate of the same speed.

Tandem primary rate target connections are those connections which are exclusively between E1, T1, V.35 PRI, X.21 PRI or 64 kb/s co-directional circuits, and whose signaling type is either bypass with signaling ("xx_Sig" in NMTI) or bypass without signaling ("xx_NoSig" in NMTI).

Generally, primary rate circuits, DCC circuits, DNIC circuits, OCU-DP circuits, DS0-DP, SRS DS0 circuits, SRM outputs, packet stream circuits, DCP-like CPSS circuits and test card DS0-TM circuits can act as maintenance circuits for 64 kb/s tandem primary rate target connections. Primary rate circuits, DCC circuits and packet stream circuits can act as maintenance circuits for superrate tandem primary rate target connections. 56 kb/s and 64 kb/s OCU-DP or DS0-DP circuits with error correction, as well as 56 kb/s DS0-TM circuits with error correction, can act as maintenance circuits for 128 kb/s tandem primary rate superrate connections.

DCC circuits, DNIC circuits, OCU-DP circuits, DS0-DP circuits, SRS DS0 circuits, SRM outputs or packet stream circuits should be used as maintenance circuits only if the tandem primary rate target connection is known to be carrying subrate data. However, this cannot be enforced by the node, since the node has no way of determining the content of a tandem primary rate connection.

Connection maintenance is always specified for the master circuit of a primary rate superrate, and always affects all circuits in the superrate group identically. It is not possible to apply connection maintenance to a single superrate slave.

The trunk conditioning pattern applied as a result of T&L maintenance is that which would normally be applied if the circuit was physically disconnected.

However, T&L maintenance and normal physical disconnections may behave differently for certain fault signaling configurations. Specifically:

- If a circuit is configured for seized fault signaling, then the seized signaling pattern will be transmitted as soon as T&L maintenance is applied. With trunk conditioning resulting from a normal physical disconnect, 2.5 seconds of idle signaling pattern is transmitted before the seized signaling pattern is transmitted.

- If a circuit is configured for OOS-C fault signaling, then the idle signaling pattern will be transmitted as soon as T&L maintenance is applied. With trunk conditioning resulting from a normal physical disconnect, OOS-C fault signaling will result in the transmission of a Yellow Alarm (T1 circuits) or Distant Alarm (E1 circuits).

- If a circuit is configured for "none" fault signaling, then the idle signaling pattern will be transmitted as soon as T&L maintenance is applied. Normal physical disconnects are not performed for circuits configured for "none" fault signaling.

- If a circuit is configured for custom trunk conditioning, then signaling code 2 pattern will be transmitted as soon as T&L maintenance is applied. With trunk conditioning resulting from a normal physical disconnect, 2.5 seconds of signaling code 1 pattern is transmitted before the signaling code 2 pattern is transmitted.

Circuits configured for idle, OOS-A or OOS-B fault signaling will trunk condition in the same fashion,

regardless of whether the trunk conditioning is as a result of T&L maintenance or a normal physical disconnect. In the case of OOS-A or OOS-B, this means that the OOS-A or OOS-B pattern will be transmitted if that pattern is not being received; if the OOS-A or OOS-B pattern is being received, then the seize pattern will be transmitted.

Data target connections are those connections involving RS-232 (V.24) DCC, X.21 DCC, V.35 DCC, RS-422 DCC, DNIC, OCU-DP, DS0-DP, DS0-TM, 4-wire TO, SRM (HCM, transparent, DDS or X.50), SRS DS0, DCP CPSS (including FRS or FRE CPSS), ITB token stream, FRS stream, or FRE stream circuits. Connections involving VCB or PCM multidrop SRM's are treated as voice.

Tandem primary rate connections which are known to be carrying subrate data can be treated as subrate data connections for the purposes of connection maintenance.

Generally, primary rate circuits, DCC circuits, DNIC circuits, OCU-DP circuits, DS0-DP circuits, SRS DS0 circuits, SRM outputs, packet stream circuits, DCP-like CPSS circuits and test card DS0-TM circuits can act as maintenance circuits for subrate data target connections. Primary rate circuits, DCC circuits and packet stream circuits can act as maintenance circuits for superrate data target connections. (56 kb/s and 64 kb/s OCU-DP, DS0-DP or DS0-TM circuits with error correction can act as maintenance circuits for similar target circuits.)

One must be careful to distinguish the maintenance ports from the maintenance circuits. Maintenance ports have some external physical interface which allows the user access to the data. Maintenance ports may be primary rate, DCC, DNIC, etc. circuits. The maintenance circuits are the circuits specified when the maintenance is being applied to the target connection. The maintenance circuits may be the same as the maintenance ports, or the

maintenance circuits may be SRM outputs or SRS DS0's; the latter have no external physical interface.

SRM inputs can never act as maintenance circuits.

Since subrate data connections are often on-card connections, it is worth re-emphasizing in this section that no form of connection maintenance can be performed on on-card connections.

Non-composite subrate data connections involve DS0's which carry only one subrate data channel.

DCC and DNIC maintenance ports can be used directly as maintenance circuits for DS0 connections carrying non-composite subrate data for all subrate multiplexing methods except DDS.

Figure 3 shows an example of split-back maintenance on a DS0 carrying non-composite HCM subrate data. The target connection is from a 9.6 kb/s DNIC circuit B1-1-A to T1 circuit A2-1; the DNIC circuit is configured for HCM subrate multiplexing. 9.6 kb/s V.35 DCC circuits B8-1 and B8-2 are the intended maintenance ports. It is sufficient to simply configure the subrate multiplexing on the V.35 maintenance ports to match the DNIC circuit, then perform the split-back maintenance using the V.35 maintenance ports as the maintenance circuits.

The restriction against using DCC or DNIC maintenance ports directly as maintenance circuits for DS0 connections carry DDS DS0A subrate data is because DCC and DNIC circuits do not support the DDS subrate formats. To perform maintenance on a target connection carrying DDS DS0A data, the maintenance circuit must be a DDS DS0A SRM output. The SRM input corresponding to the DDS DS0A SRM output can be connected to an HCM_DDS DCC maintenance port.

Figure 4 shows an example of split-back maintenance on a DS0 carrying a DDS DS0A. B1-1-A is a 9.6 kb/s DNIC

circuit, configured for HCM_DDS, which is connected to DDS DS0A SRM input B1-1-B1 on a DPM2 on the DNIC card. The DDS DS0A SRM output B1-1-M1 is connected to T1 circuit A2-1. 9.6 kb/s V.35 DCC circuits B8-1 and B8-2 are to be used as split-back maintenance ports. Since the connection from B1-1-A to B1-1-B1 is an on-card connection, no maintenance is possible on this connection; maintenance must be performed on the SRM output to T1 connection. An additional DDS SRM resource, B7-1, must be used to perform conversion from DDS DS0A to DDS_HCM. The maintenance ports B8-1 and B8-2 are configured for DDS_HCM. B8-1 is connected to B7-1-M1 via input B7-1-B1, and B8-2 is connected to B7-1-M2 via input B7-1-B2; these are normal (non-maintenance) connections. Split-through maintenance is then applied on the connection between B1-1-M1 and A2-1, using B7-1-M1 and B7-1-M2 as maintenance circuits. Note that exactly the same approach could be taken for monitor or split-through maintenance.

Figures 5a - 5c show maintence applied to a circuit with protection. Figure 5a shows all circuits ready, both preferred split-back connections physically connected, Figure 5b shows splitting circuit S1 not ready: split-back connection between A and S1 physically disconnected, but no protection switch; split-back connection between B and S2 remains physically connected; and Figure 5c shows target circuit B not ready: Switch to protection connection occurs.

For example, assume that the connection between A and B is split-back by circuits S1 and S2:

- The connection between A and S1 will be physically connected only if both A and S1 are ready.

- The connection between B and S2 will be physically connected only if both B and S2 are ready.

- Note that it is possible for the connection between A and S1 to be physically connected while the connection between B and S2 is not physically connected, or vice-versa.

- If both A and B are ready, there will be no attempt to perform a switch to the protection connection between A and C, regardless of the status of S1 and S2.

- If both A and C are ready while B is not ready, there will be a switch to the protection connection between A and C, regardless of the status of S1 and S2.

Figure 6a shows all circuits ready: preferred connection physically connected; split-back connection between C and S2 also physically connected; and Figure 6b shows target circuit B not ready: switch to protection connection occurs; split-back connection between A and S1 physically connected; split-back connection between C and S2 not disturbed.

Assume that the protection connection between A and C is split-back by circuits S1 and S2:

- The connection between C and S2 will be physically connected only if both C and S2 are ready, regardless of any physical connection involving A .

- The connection between A and S1 will be physically connected only if both A and S1 are ready, and B is not ready.

The first point in the above paragraph is significant: it allows split-back maintenance to be physically connected on a protecting circuit (C) while the protected

circuit (A) is physically connected at the preferred level.

For split-through maintenance, if any of the target or maintenance circuits in the connection are not ready, the connection cannot be physically connected.

Consider the network shown in Figure 7. The primary path from SFO to NYC passes through nodes in KC and CGO; an alternate path passes through nodes in DNV and DAL. The path in use is shown in heavier lines; protection connections are shown with dashed lines.

The connections made on any intermediate nodes are preferred connections, regardless of whether the intermediate nodes are on the primary or alternate paths. Also, all circuits in the preferred path are configured for OOS signaling; circuits in the alternate path are configured for idle signaling. Assume that, initially, there are no failures on the network; therefore, the primary path will be active. However, the circuits on the DNV and DAL nodes will also be physically connected, since their connections are programmed at the preferred level. For simplicity, assume that the user's MOP's reserve link B8-B as a TAD for all nodes, and that test equipment is co-located with each node.

The connections are listed as:

SFO A8-A-1 connected to A3-A-1 protected by A3-B-7;
KC A1-A-1 connected to A2-A-6;
CGO A4-B-6 connected to A3-A-14;
NYC A5-B-1 connected to B7-B-14 protected by A5-A-4;
DNV B1-A-7 connected to B1-B-16;
DAL B2-A-16 connected to B2-B-4.

The user may want to verify the integrity of the alternate path while the preferred path is in service — users typically do not want to wait until a switch to a protection path is attempted to find out that there is something wrong with the alternate path.

To do this, split-back maintenance is applied to the protection connection at the endpoint nodes:

SFO A8-A-1 (already protected by A3-B-7) split back by B8-B-1 and B8-B-2;

NYC A5-B-1 (already protected by A5-A-4) split back by B8-B-1 and B8-B-2.

Now, SFO A8-A-1 and NYC A5-B-1 are already physically connected at the preferred level; split-back maintenance at the protection level will not physically affect these circuits. However, SFO A3-B-7 and NYC A5-A-4 are not physically connected; therefore, they can be physically connected to their respective splitting-back circuits. This allows the test sets at SFO and NYC to exchange data along the alternate path. Test patterns transmitted into SFO B8-B-2 should be received at NYC B8-B-2, and vice-versa: the alternate path is tested without disturbing the preferred path (See Figure 8).

Note that while the alternate path is under test, it is not truly protecting the primary path. If a switch were to occur to the alternate path while it is under test, the connection maintenance would not be automatically removed. Instead, the test would also be applied to the tail circuits (SFO A8-A-1 and NYC A5-B-1), and the PBX's would get a burst of whatever test patterns. Therefore, it is recommended that connection maintenance used to test alternate paths be released as soon as the test is completed. Also, to prevent the propagation of test patterns into the tail circuits should a switch occur, T&L maintenance could be applied to trunk condition the tail circuits at the protected level for the duration of the tests. This T&L maintenance will have no effect if no switch occurs to the alternate path occurs.

Now assume that the link between KC and CGO breaks. (Also assume that any connection maintenance on the protection connections has been released.) KC will begin transmitting OOS signaling towards SFO; CGO will begin

transmitting OOS signaling towards NYC. SFO and NYC will declare circuits A3-A-1 and B7-B-14, respectively, out of service, and perform a switch to the protecting connection.

Connection maintenance can be used at this point to ensure that network does not automatically switch back to the primary path when the link between KC and CGO is restored. Two instances of one-way T&L maintenance are applied, such that KC is trunk conditioning towards SFO, and CGO is trunk conditioning towards NYC. Of course, this T&L maintenance is redundant while the link between KC and CGO is broken; that trunk conditioning would have been applied anyway.

However, once the link between KC and CGO is restored, T&L maintenance will keep the preferred circuits at SFO and NYC out of service, and therefore keep the alternate path active. Split-back connection maintenance can be applied as follows:

KC A1-A-1 (already connected to A2-A-6) split back by B8-B-1 and B8-B-2;

CGO A4-B-6 (already connected to A3-A-14) split back by B8-B-1 and B8-B-2.

Referring to Figure 9, test patterns sent into KC B8-B-2 should be received by CGO B8-B-1, and vice-versa. Once the craftsperson has been convinced that service is in fact restored between KC and CGO, the split-back maintenance can be removed.

Removing the T&L maintenance can be difficult. The preferred circuits at SFO and NYC should come back into service nearly simultaneously. This is to prevent some period where one endpoint has the preferred connection active while the other endpoint still has the protection connection active, and therefore neither path properly active. Such a period is probably unavoidable there is an attempt to manually release T&L maintenance at both

the KC and CGO nodes simultaneously. The proper procedure is to apply two-way T&L maintenance at either KC or CGO, and to release the T&L maintenance at the other intermediate node. One node will then be transmitting the OOS signaling in both directions. Finally, the two-way T&L maintenance at that node is removed; this will result in the near-simultaneous cancellation of OOS transmission in both directions, and SFO and NYC should switch back to their preferred connections at about the same time.

Now consider the case where the preferred links to one of the endpoint nodes is broken, say the link between KC and SFO. In this case, connection maintenance is useless. The same T&L maintenance as above could be used to prevent a switch back to the primary path when the link between KC and SFO is restored. However, this same T&L maintenance would keep the circuit KC A3-A-1 out of service. Since it is out of service, it can't be physically connected. Since it can't be physically connected, connection maintenance involving that circuit cannot be physically connected. Therefore, connection maintenance cannot be used to test the restored link between SFO and KC.

To solve this problem, a true non-revertive switch must be implemented. Currently, the node implements purely revertive switch, which means that a switch will occur from the protection connection to the preferred connection as soon as all of the circuits in the preferred connection are ready. Non-revertive switching means that if the protection connection is physically connected, then a switch to the preferred connection will not occur as soon as all of the circuits in the preferred connection are ready; instead, such a switch from the protection connection to the preferred connection must be manually initiated by the craftsperson. Such a switch would typically not be made until the craftsperson had

verified the integrity of the primary path using connection maintenance.

When a maintenance connection is applied or removed, the statuses of the target and maintenance circuit records maintained by the network manager must be updated accordingly. Their status must change based on their current status and the action just taken. Figures 10 and 11 give the transitions for the target and maintenance circuit statuses.

The state diagram for the target circuit status is identical to that of a regular circuit.

It should be noted that:

- Circuits of unidirectional connections, which can only be created from NMTI, will have a DB_CT_NMTI_CONNECTED status.
- Reconnecting a maintenance circuit to another circuit (not involved in any maintenance connection) from NMTI will remove the maintenance connection; once the circuit is reconnected, the status of the maintenance circuit will be DB_CT_NMTI_CONNECTED.
- Using a maintenance circuit in a new maintenance connection when that circuit is already involved as a maintenance circuit in an existing maintenance connection will disconnect the first maintenance connection, then create the second.

The routine calculate_circuit_status() handles the state transitions for both the target and maintenance circuits as described above. The parameter that currently indicates whether the circuit is being connected or disconnected will have another value to indicate when a circuit is being maintained (MAINTENANCE_FLAG). When a maintenance connection is added, the target circuit is considered to be maintained (MAINTENANCE_FLAG) while the

maintenance circuit is considered to be connected (CONNECT_FLAG).

In addition to their status field, the target and maintenance circuits' maintenance fields will also be updated. This will be done within the routine db_update_conn_circuit() (formerly called db_update_conn_circ_status()). Note that the constants used for the maintenance field have bitwise values. In addition, the constants used for the target circuits include level information as well. This allows for identifying when maintenance is being applied at both levels of a branch target connection. For example, if the branch of a RAPID path has slit-thru maintenance on the primary level and monitor maintenance on the alternate level, then the branch target circuit's maitenance field will have the value 0x101.

When a loopback is applied on a circuit involved in a path, the path is considered intruded. A routine db_update_intruded_count_for_loopback() updates the intruded field in the call_att record associated with the circuit when a loopback is added or removed. This routine will be called by db_update_circ_conn_info() and by db_update_circ_post_save_default().

When a target circuit is pasted into the Diagnostics window, the mate target circuit must be determined and the Test Equipment A and Test Equipment B fields must be automatically filled in with the maintenance circuit ids. The routine db_get_mate_target_circ_id() will be called to determine the mate target circuit while db_get_maintenance_circ_ids() will be called to retrieve the maintenance circuit ids.

A routine db_list_all_circ_looped_and_maintained() lists all circuits that currently have loopbacks or maintenance connections.

Maintenance connections are always saved as conn records in the database. The number of conn records added depends on the maintenance type. For a monitor maintenance connection, a total of 2 conn records are added, one for each target and maintenance circuit pair. For a split-through maintenance connection a total of 4 conn records are added, one for each target and maintenance circuit combination (i.e. target circuit 1 - maintenance circuit 1, target circuit 1 - maintenance circuit 2, target circuit 2 - maintenance circuit 1, and target circuit 2 - maintenance circuit 2). For a superrate maintenance connection, these conns are added for each target circuit in the superrate bundle; for example, a monitor maintenance connection applied on a 3 DS0 superrate bundle will add 6 conns in the database. These connections are given a status according to the type of maintenance being applied and the level.

For each undirectional connection, one conn record will be added in the database with DB_UNIDIRECTIONAL_PRI/ALT_CONN status. The order of the circuits in the conn id will indicate the source and destination of the undirectional connection, ie: the first circuit is the source and the second circuit is the destination.

The conn records saved in the database have a pair of circuit ids as their ids. For a maintenance conn record, the circuit ids used in the maintenance conn id will be ordered such that the target circuit is always first and the maintenance circuit second. This ordering is required for BWA. For a unidirectional or broadcast conn record, the first circuit is that of the source circuit and the second is the destination circuit, as mentioned above. The routine db_order_conn_id() will NOT be used to handle the circuit ordering for maintenance, unidirectional, and broadcast conn records. The ids are ordered when the conn records are saved in the database

and when they are handled. For example, db_get_conn() will be modified to be able to handle retrieving these new types of conn records.

Similarly, when a maintenance connection is added from the network manager, the routine db_add_maintenance_conn() is called. This routine calls db_nci_add_conn() for each maintenance connection component. db_add_maintenance_conn() includes the target and maintenance circuit ids and the maintenance type as parameters.

When a maintenance connection is added, db_nci_add_conn() first checks whether the connection exists in the database. If not, the conn record is added. If it is the first component of a maintenance connection, the status of the target connection is updated accordingly. The new target connection's status is based on the state diagram shown in Figure 12.

Note that "PRI" type states can be interchanged for "ALT" type states. For example, downloading a DB_4602_ALT_CONN conn will change its status to DB_NMTI_ALT_CONN.

The routine db_GetConnLevel(), called from db_nci_add_conn(), returns a connection's level (primary or alternate) based on its status. It handles the new conn statuses that are being added. The routine db_update_conn_circuit() which is called to update the circuits of the conn record is modified to handle the target and maintenance circuits. This includes updating the maintenance field in the circuit record.

When a maintenance connection gets disconnected from the node, it sends notification to CHG_notif for each maintenance circuit involved. CHG_notif calls the routine db_remove_conns_for_circ() for any type of disconnection done from the node. If it is a maintenance connection, db_remove_conns_for_circ() calls db_remove_maintenance_connection() which will remove the

maintenance connection by calling db_nci_del_conn() for each component of the connection. When a maintenance connection is removed, db_remove_maintenance_connection() is called as well.

db_nci_del_conn() will change the target connection's status when the connection being deleted is a maintenance connection. If the target connection is part of a path, its call_att maint_pri/alt_count and intruded fields will be updated as well. All components of the maintenance connection will be removed when the delete notification is received for the first maintenance circuit. Subsequent notifications will not cause any additional updates.

The changes to be made to the routines for deleting maintenance connections are similar to those being done for adding them

The invention thus allows a network to be monitored in a particularly conveninent manner from a single location using common test equipment for all the nodes.

Claims:-

1. A method of monitoring a network having a plurality of nodes, wherein a path is set up to carry traffic between two points on said network, characterized in that said method comprises the steps of:

a) providing a test device at a predetermined common test site for the network;

b) setting up cross-connections with a network manager from a single location on the network between said test device and said nodes on said path; and

c) monitoring said path through said cross-connections with the aid of said test device.

2. A method as claimed in claim 1, characterized in that it further comprises successively monitoring the individual connections forming said path.

3. A method as claimed in claim 1, characterized in that the connections are first monitored to ensure that they are not currently carrying an active call, and if not terminate and leave monitoring is applied.

4. A method a claimed in claim 3, characterized in that test patterns are injected into the connections under test and monitored by said test device using said cross connections.

5. A method as claimed in claim 1, characterized in that a point-and-click paradigm is employed to set up said connections.

6. A method as claimed in claim 1, characterized in that said path comprises a preferred path and a protection path for carrying traffic in the event of a fault on the preferred path, and said protection path is monitored while the preferred path is active.

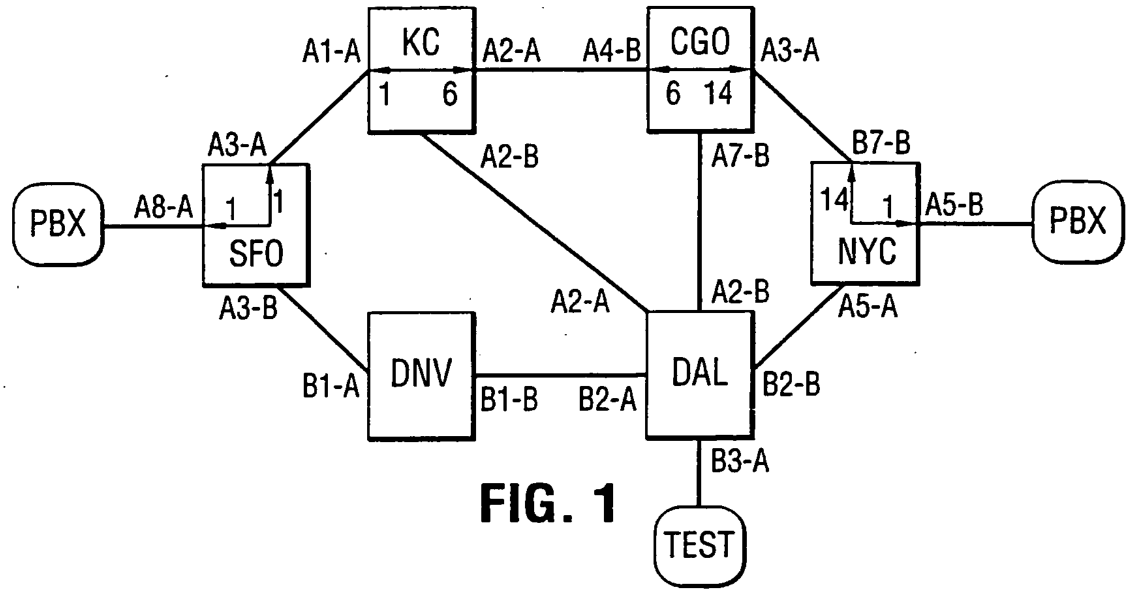

FIG. 1

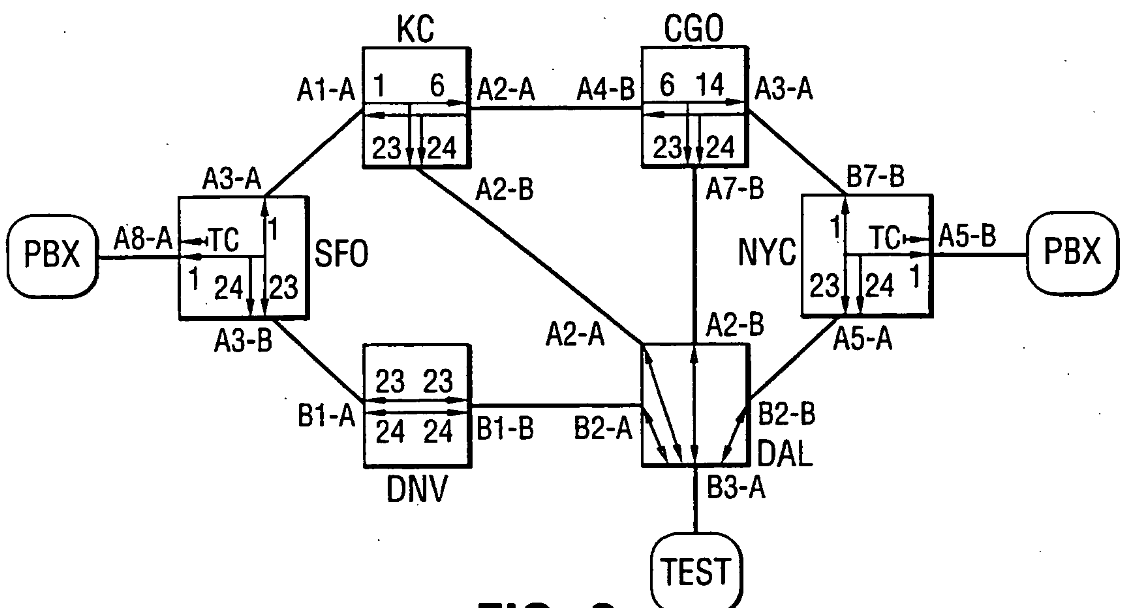

FIG. 2

SUBSTITUTE SHEET

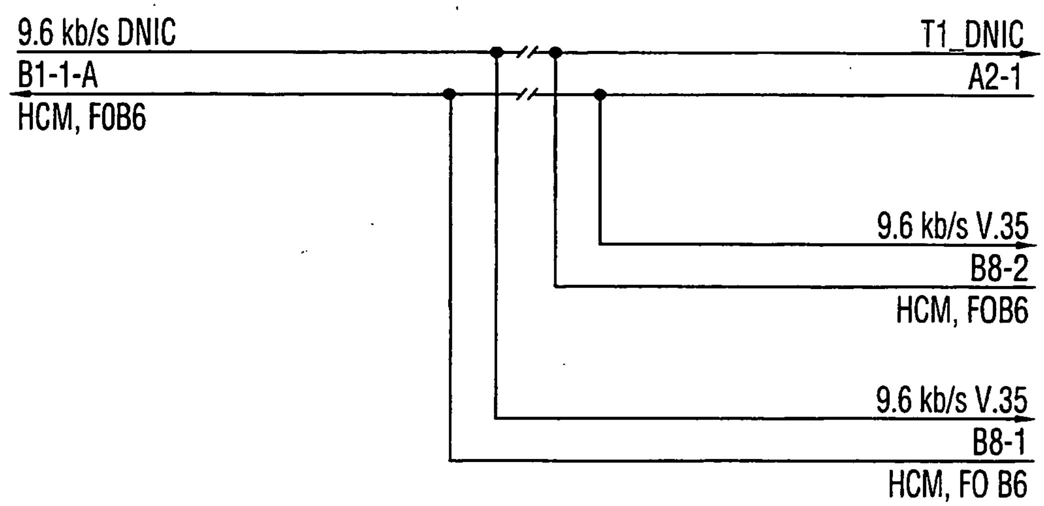

FIG. 3

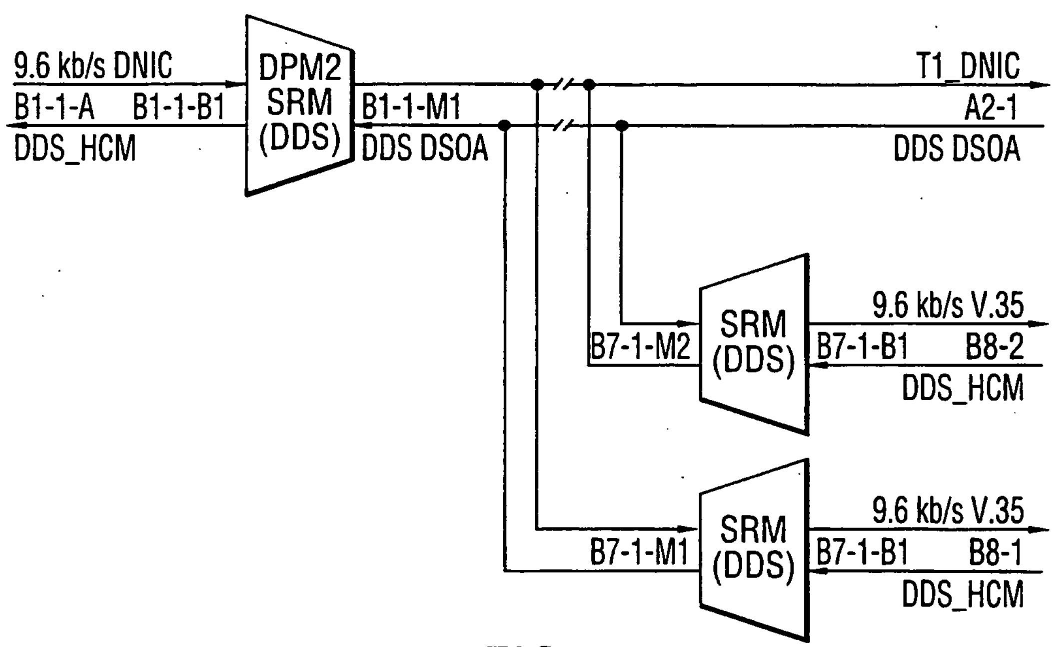

FIG. 4

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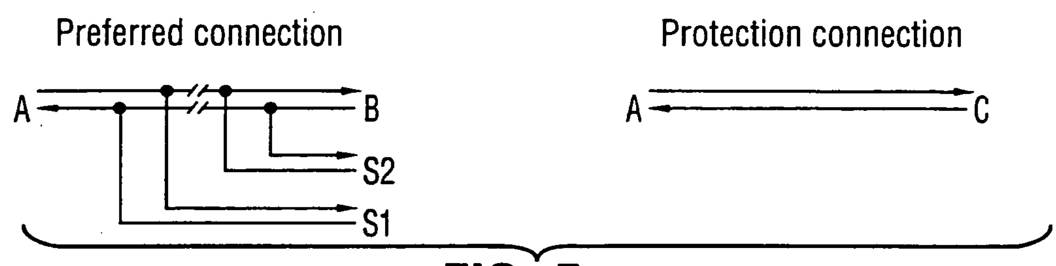


FIG. 5a

FIG. 5b

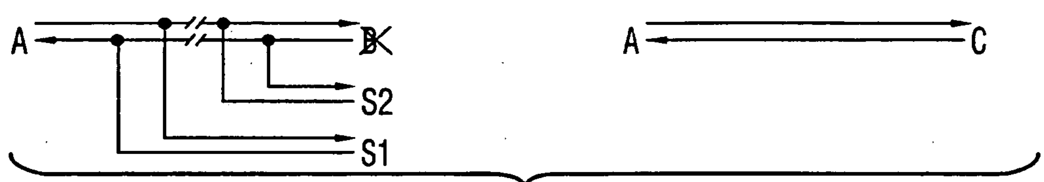


FIG. 5c

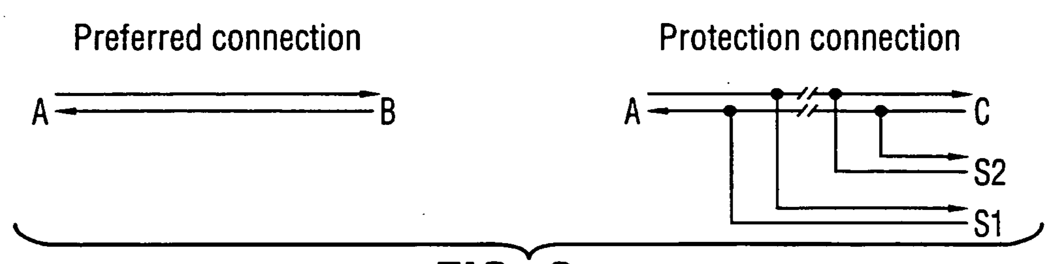
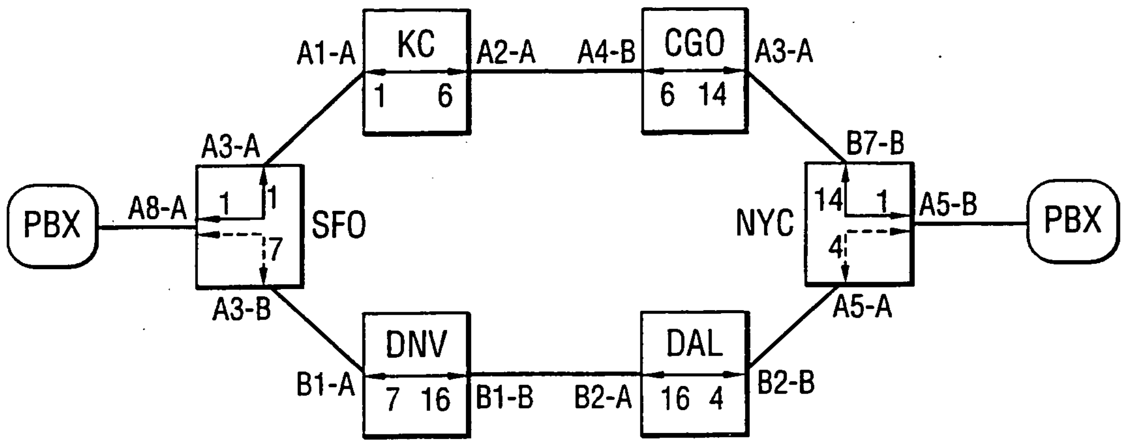


FIG. 6a

FIG. 6b

SUBSTITUTE SHEET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NYC
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DAL
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A4-B
A3-A
A3-A
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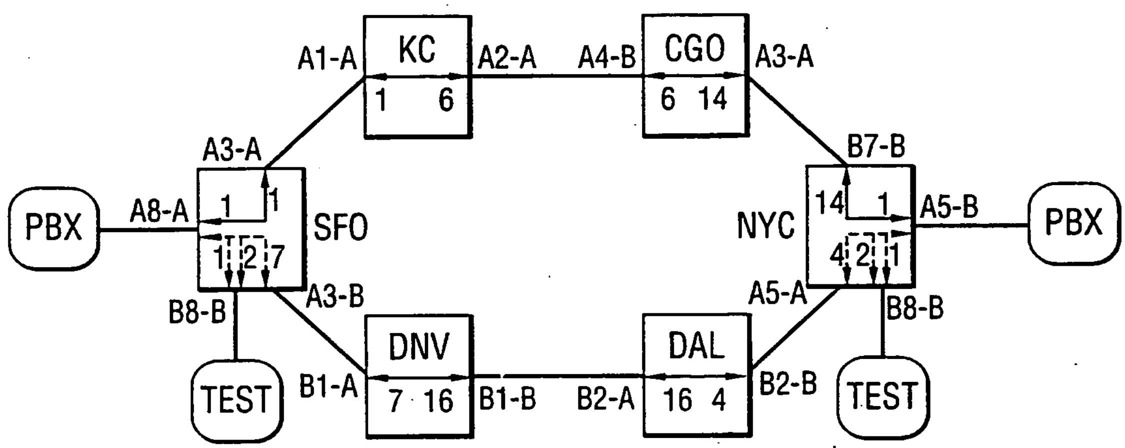
A8-A
A5-B
A3-B
A5-A
B1-A
B1-B
B2-A
B2-B
1 6
6 14
7 16
16 4

FIG. 7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A3-B
A5-A
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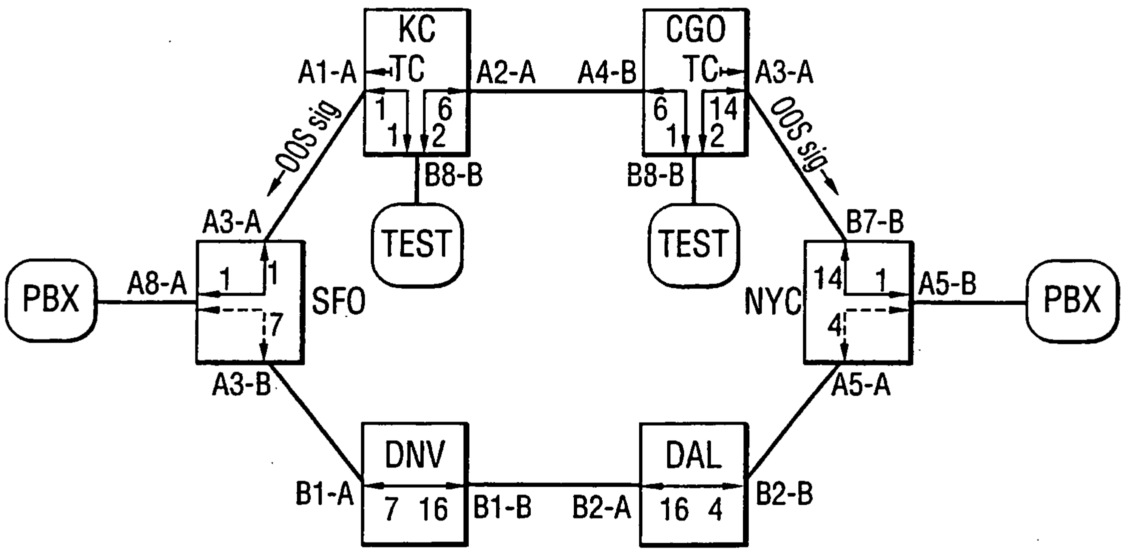
B1-A
B1-B
B2-A
B2-B
1 6
6 14
7 16
16 4

FIG. 8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A2-A
A4-B
CGO
TC
A3-A
OOS sig
OOS sig
1
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6
2
6
1
14
2
B8-B
B8-B
TEST
TEST
A3-A
B7-B
PBX
A8-A
1
1
7
SFO
NYC
14
1
4
A5-B
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B1-A
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B2-A
16 4
B2-B

FIG. 9

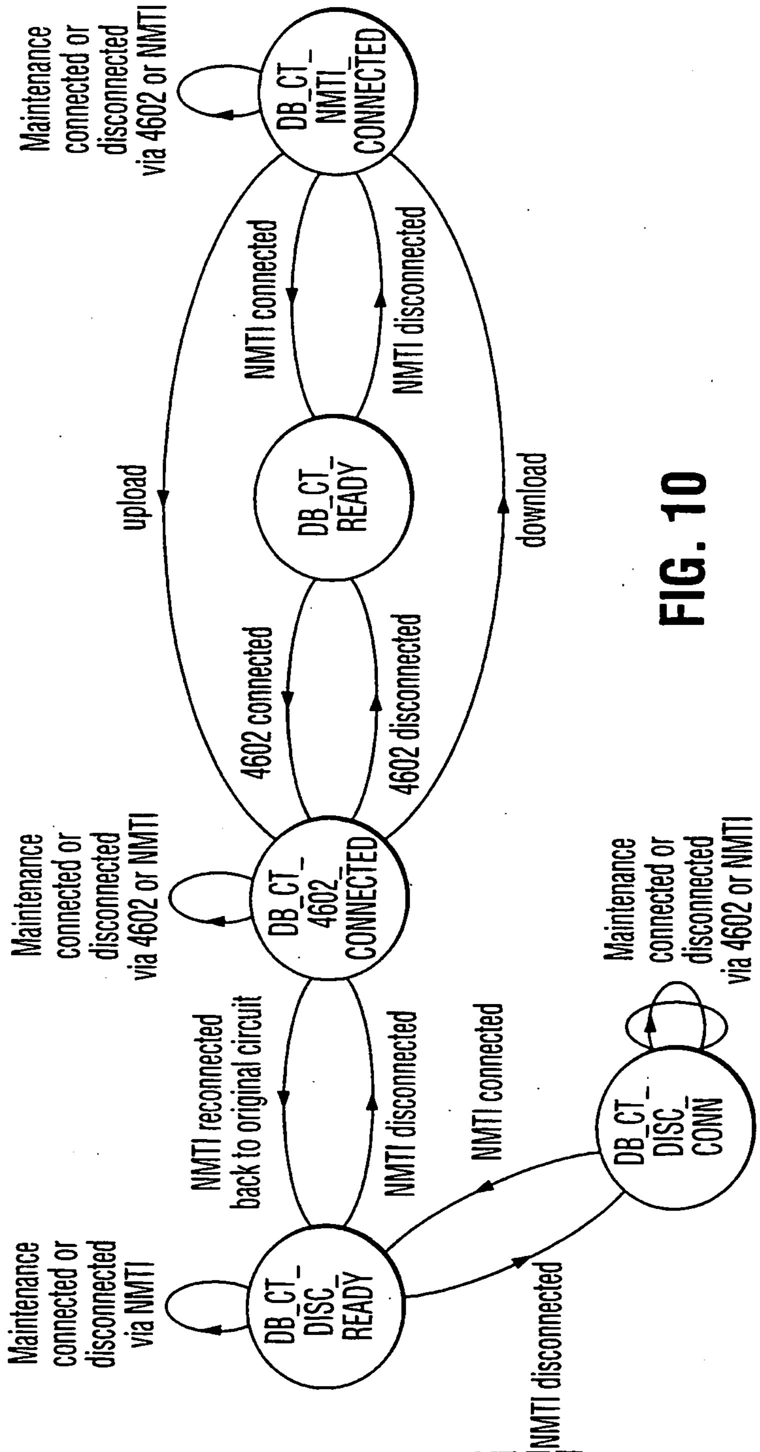

FIG. 10

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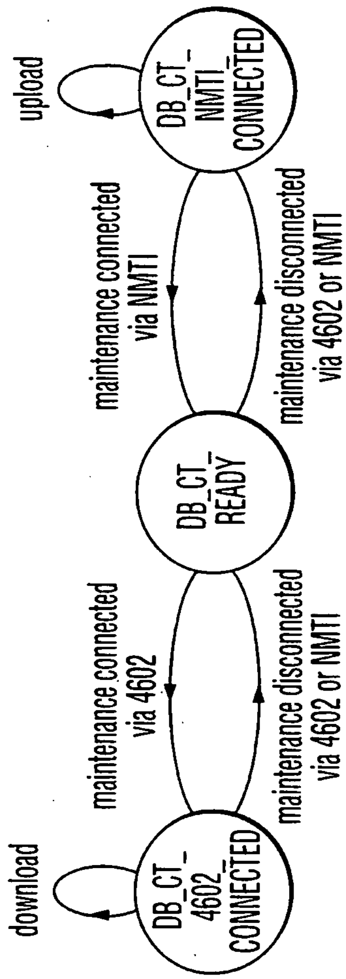

FIG. 11

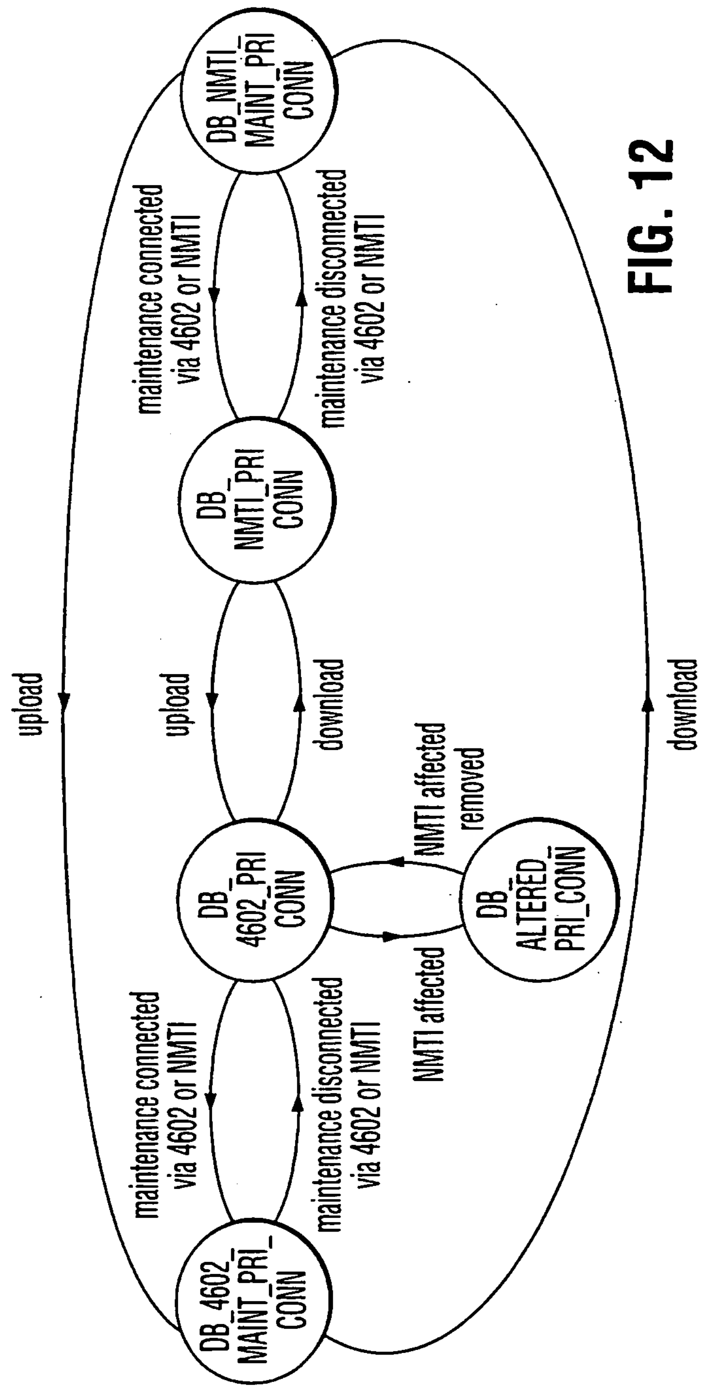

FIG. 12

SUBSTITUTE SHEET

ERNATIONAL SEARCH REPORT

Interna Application No
PCT/CA 95/00330

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04M3/22 H04M3/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	IEEE GLOBAL TELECOMMUNICATIONS CONFERENCE, vol. 2, 1 December 1986 - 4 December 1986 HOUSTON(US), pages 1179-1184, J.F.MARSHALL ET AL 'AUTOMATIC CROSSCONNECTION EQUIPMENT IN BRITISH TELECOMS KILOSTREAM NETWORK' see page 1180, right column, line 4 - line 17 ---	1,2
X	DE,A,31 10 633 (VIERLING) 30 September 1982 see page 5, line 7 - line 21 see page 6, line 33 - page 11, line 14 see page 14, line 12 - line 30 ---	1-4,6

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
11 September 1995	06. 10. 95

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Vandevenne, M

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US,A,4 001 559 (OSBORNE) 4 January 1977 ---	
A	IEEE 1992-NETWORK OPERATIONS AND MANAGEMENT SYMPOSIUM, vol. 3, 6 April 1992 - 9 April 1992 MEMPHIS(US), pages 709-720, MYRANDA A. JOHNSON ET AL 'NEW SERVICE TESTING FUNCTIONS FOR ADVANCED INTELLIGENT NETWORKS' -----	

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/CA 95/00330

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		JP-A-	51092641	13-08-76
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		SE-A-	7514222	17-06-76